

HOMEWORK IN AN INTRODUCTORY COLLEGE MATHEMATICS CLASS:
ITS PURPOSE, EFFECTS, AND STUDENTS' OPINIONS

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ABSTRACT

Homework has been a central topic of study for over 80 years. This study investigated 1) the opinions of a class of introductory college mathematics students on the purpose of homework in their class, 2) their professor's opinion on the purpose of mathematics in the class and whether any differences between the students' and the teacher's opinion had any effects on the students, and 3) whether time-spent on homework correlated positively with grade expectation in the class.

Research took place over a one year period, involving first-year engineering students taking multi-variable calculus. Students were given a survey, asking a number of questions, including: what they believed to be the purpose of homework, how many hours per week they spent on homework, and what they expected would be their grade in the course. Their professor was then interviewed in email correspondence and provided her views on the purpose of homework and its relationship to learning and examinations.

This study found that the vast majority of students in the class viewed homework as practice and review of ideas already presented in lecture. Their professor also thought the purpose of homework was for practice and review, but had other purposes, including the application of learned material to thought-provoking problems, and integrating old knowledge with new knowledge. As a possible effect, the few students who selected higher cognitive purposes of homework, such as the synthesis of new ideas not previously presented, and the evaluation of one's own understanding, tended to expect higher grades than their peers. Lastly, the correlation between grade expectation and time spent on homework was positive up until a point, whereafter the correlation became negative. This point coincided with the expected amount of time to spend on homework given by the professor, but whether this was the cause of the change in correlation was not proven. It did indicate, however, that

the assumption that homework had a purely positive correlation with grade expectation at the collegiate level was tenuous.

BIOGRAPHICAL SKETCH

Jeffrey King was born on July 9, 1986 in Elmira, NY and grew up in Athens, PA. After graduating from Athens Area High School in 2005, he attended Cornell University and graduated *cum laude* in mathematics in 2009. Wishing to begin studies in mathematics education, he continued at Cornell, receiving an MS in Education in January of 2011. When not studying mathematics education, he sings, plays the piano, plays chess, and is an avid basketball fan.

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I must also thank Barbara Crawford, my second Committee member, for her honesty and perspective in helping me come to grasp with the ideas for this thesis. Her encouragement gave me the confidence to fully pursue this study, while her passion and joy that she has for her work are qualities that I wish to emulate.

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Introduction

As a teaching assistant for Math 1920, Multi-Variable Calculus for Engineers, one of most common and difficult questions posed by my students was the following: “Why are we doing this?” Not only did this concern the applications and sensibility of the abstract mathematical concepts that the students were dealing with, but it also dealt with the various pedagogical structures of the class. The most notable of these were the questions regarding their homework. From the first week of class, students loudly and repeatedly questioned their homework, asking, “Why are we doing this? Why does it have to be so hard? What am I supposed to be getting out of this?” After weeks of receiving the same question from students of all different backgrounds and abilities, I decided to pursue the question academically and research the purpose of introductory college mathematics homework.

Speaking with my thesis advisor, Professor David W. Henderson, he introduced me to the Master's thesis of (now) Professor John Volmink, for whom he served as chairman. Professor Volmink's thesis, *Meaning in Mathematics: On Integrating Thinking, Feeling and Acting in a First-Year Calculus Course*, studied the differences in the meaning of mathematics between undergraduate students, graduate students, and professors (Volmink, 1983). Using this as inspiration, I decided to study the differences of the beliefs on the purpose of homework between my undergraduate students and their professor.

The question soon transformed from “what is the purpose of homework?” to “how does one study the purpose of homework?” The problem has been studied extensively at the elementary and secondary school levels, but it has almost never been studied in mathematics at the collegiate level. Looking in the elementary and secondary school education research, I found the work of Professor Pamela M. Coutts, *Meanings of Homework and Implications for Practice* (Coutts, 2004). Similar to the work of Volmink, Coutts compared the opinions of secondary and elementary school

students with the attitudes of their adult superiors (in this case, their parents and teachers; professors and graduate students in the case of Volmink), regarding homework instead of mathematical meaning. As such, I would use a similar approach, comparing college student opinions to elementary and secondary school students.

Homework also had been shown to have different *effects* at the elementary and secondary school levels, as shown in the work of Muhlenbruck and others, *Homework and Achievement: Explaining the Different Strengths in Relation at the Elementary and Secondary School Levels* (Muhlenbruck, et al, 2000). Namely, that there was a higher correlation between homework and achievement in secondary school than in elementary school. In studying the purpose of homework, I wanted to see if homework and achievement had a positive correlation at the collegiate level.

This thesis looked at: 1) comparing the opinions of a class of college students on the purpose of homework to their secondary and elementary school counterparts, similar to Coutts comparing elementary and secondary school students' opinions (Coutts 2004); 2) comparing the opinions of the students and their professor and whether any differences had an effect on the students, similar to Volmink studying the differences in the meaning of mathematics between professors and students (Volmink 1983); 3) whether homework had a positive correlation with achievement at the collegiate level, as an extension of the work of Muhlenbruck and others studying the strengths in relation between homework and achievement in elementary and secondary school students (Muhlenbruck, et al, 2000). For the first, I decided to conduct a survey asking the students what they felt was the purpose of homework from a wide-ranging list of well-accepted purposes of homework at the elementary and high school levels. For the second, I would survey the students on whether they felt their chosen purpose had been accomplished, as well as their grade expectations, and then interview their professor in order to compare her thoughts to their responses. For the third, I would survey the amount of time students spent on homework and compare it

to their grade expectations to investigate whether time spent on homework correlates positively with achievement.

Literature Review and Motivation

Homework can be defined as any activity assigned by a teacher for students to do outside of class hours (Cooper, 1989). Many studies cite the positive effects of homework, including increasing student time spent on academic studies (Walberg & Paschal, 1995), improve study habits and attitudes (Warton, 2001), and promoting self-efficacy (Corno, 1994). Others cite the negative effects of homework, including causing students to dislike school, as well as taking time away from leisure activities (Coutts, 2004). In addition to the many academic purposes of homework outlined above, homework has also been shown to have many non-academic purposes. These include involving parents in students school-work (Van Voorhis, 2003) and inform parents of school directives and activities (Corno, 1996).

At the primary and secondary school levels, the academic purposes of homework can be grouped into two general categories, instructional and non-instructional (Epstein, 1988). Instructional purposes include: (1) the opportunity to practice or review already presented in class (Becker & Epstein, 1982), (2) introduce new material to students in preparation for a future lesson (Muhlenbruck, Cooper, Nye, & Lindsay, 1999), and (3) extend and integrate learned skills (Lee & Pruitt, 1979). Coutts also suggests a set of non-instructional purposes, including: (4) Encouraging student self-regulation (Coutts, 2004), (5) teaching students time-management skills, (Coutts, 2004), and (6) development of a student's individual work ethic (Coutts, 2004).

In Coutts' study, opinions strongly varied between the parents and among the students themselves. When asked to state their beliefs on the purpose of homework, parents generally responded in terms of long-term development, such as learning of

time-management skills and developing a student's intrinsic desire to learn (Coutts, 2004). Students in elementary school cited extrinsic motivations as the purpose of homework, such as pleasing their parents or their teacher. Some did, however, reference long-term purposes of homework, such as preparation for homework in future classes. This contrasted with secondary school students, who believed that homework focused on consolidation and revision (Coutts, 2004).

When achievement is represented by grades and standardized test scores, homework has been shown as a means to increase both motivation and academic time, both positively correlated with achievement (Singh, Granville, & Dika, 2002). Others claim that the correlation between homework and achievement is more opaque, citing the many factors influencing the effects of homework, including teacher style, grade level, and homework and grading structure (Trautwein & Koeller, 2003). Others also cite the difficulty in differentiating between individual influence and school-wide influence on homework and achievement (Trautwein, 2007).

John Volmink found that in his class, mathematics students typically searched for a greater meaning to the problems and material they were presented (Volmink, 1983). This search was inhibited by their professors holding the false beliefs that (a) students do not want to learn the meaning behind mathematics, (b) only a small amount of them will have the ability to grasp it, (c) mathematics is a meaningless activity and a search for meaning is “often an allusion to an inability to do mathematics very well” (Volmink, 1983). This was reinforced by the grade system of the course, which focused on the use of techniques and algorithms stripped of their meaning.

It has been shown that the correlation between time spent on homework and achievement increases greatly in secondary school as compared to elementary school (Muhlenbruck et al, 2000). Possible reasons for this included 1) homework serving different purposes at the elementary and secondary school levels and 2) lower

achievers taking more time than higher achievers to finish the same homework both receiving partial support, and 3) elementary students receiving less homework than secondary students and 4) teachers giving homework to students who are having trouble both receiving little support.

Research Questions

This thesis attempts to begin answering the following questions: 1) “Do introductory college mathematics students hold different beliefs about the purpose of homework compared to secondary and elementary school students?” similar to Coutts' study on the differences between secondary and elementary school students' opinions on homework (Coutts, 2004); 2) “Does their professor hold a different belief about the purpose of homework, and does this affect the students in any way?” similar to Volmink's study on the differences between students' and their professor's beliefs on the meaning of mathematics (Volmink, 1983); 3) “Does there exist a positive correlation between homework and grade expectation at the college level?” as an extension of the work of Muhlenbruck and others examining the differences in strengths of relation between homework and achievement in elementary and secondary school (Muhlenbruck, et al, 2000).

Methodology

There were two data sources to this study. First, the researcher administered a survey given to the students in order to obtain basic data regarding the students' perceptions on the purpose of homework. From this survey, questions 8-9, 11, and 13-15 were used in the analysis of this study, with questions 13-15 designed specifically for this study. The full survey can be found in the appendix. The survey was given to the students two weeks before their final exam. The questions used from the survey consisted of the following questions on a 1-5 scale:

8. Rate the examinations in this course as a test of your knowledge.

1 = too easy, not adequate

3 = adequate

5 = too difficult, not a fair test

9. Rate the level of difficulty of this course.

1 = too easy

5 = much too hard

11. How many hours each week (on the average) did you spend on this course outside of class?

1 = less than 2 hours

2 = 2-4 hours

3 = 5-8 hours

4 = 9-15 hours

5 = 16 hours or more

13. Choose which statement best reflects your beliefs: I believe that the chief purpose of homework in this course should be to...

1 = help me practice and review material already presented in lecture.

2 = introduce me to new material as preparation for a future lecture.

3 = help me integrate previously learned material with new material.

4 = help me evaluate what parts of the material I do not understand.

5 = encourage me to learn during leisure time.

6 = improve my study habits.

14. State how strongly you agree or disagree with the following statement: The homework in this course helps me to achieve the purpose chosen above.

1 = strongly disagree

5 = strongly agree

15. Without taking into account the final exam, which do you believe is closest to your current grade in this course?

1 = A

2 = B

3 = C

4 = D

5 = F

Questions 1-12 of this survey were part of the student course evaluations that were standard for all introductory math courses at the university. Questions 13 was written in the first-person so that students would respond with *their* purpose of homework, and not the purpose of homework that they believed was part of the course

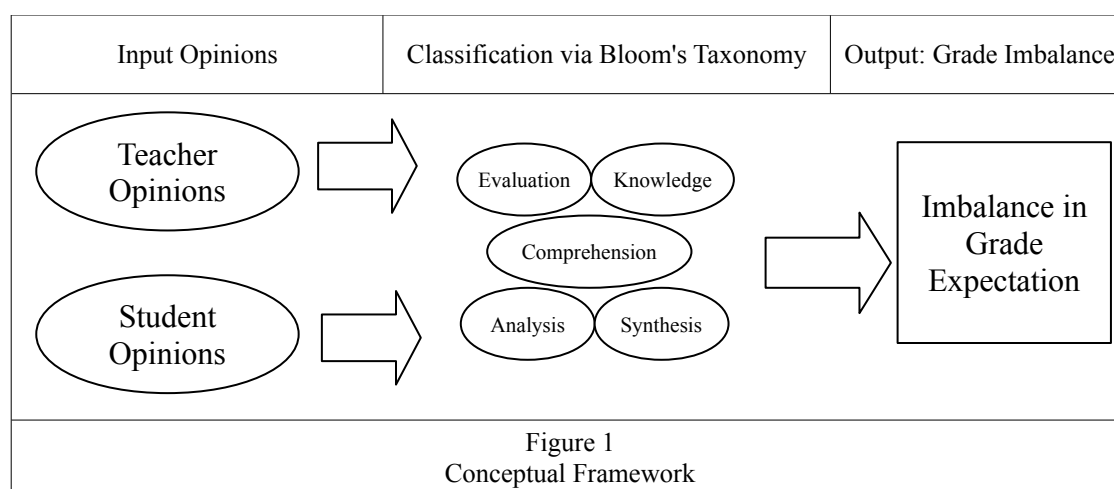
or their professor's purpose of homework. Similarly, Question 14 was written in the first-person so that the students would respond with *their* belief as to how well the course achieved the *student's* purpose of homework. Question 15 was used as a basis for student understanding, under the assumption that the student's self-perceived level of understanding would be reflected in their grade expectation. The students were divided into two groups: above average (expecting A and B grades) and below average (expecting C, D, or F grades). The use of actual grades would have been too heavily influenced by the examinations, while the focus of this study was the effects of homework. Also, the use of actual grades was ethically questionable due to the researcher's role as a teaching assistant in the class.

The second data source was a series of email questions posed to the professor of the class regarding the professor's ideas on the purpose of homework in the context of this class. The goal of these questions was to understand the professor's views on homework such that they could be compared to the students' views. A copy of these questions and the professor's responses can be found in the appendix.

Conceptual Framework

The students' opinions and their teacher's opinions on the purpose of homework acted as independent variables, two of the many which act upon the dependent variable of *grade imbalance*. By the use of grade imbalance, this study made the assumption that if the students and teachers opinions on the purpose of homework had no effect on grade expectations, then the student grade expectations should have been proportional to the number of students in each grade level. For example, if 30% of the students chose a particular purpose of homework, then 30% of the above average students should have chosen that same purpose, as well as 30% of the below average students. If there was an imbalance, an example being 10% of the above average students chose a particular purpose, but 30% of below average students

chose that same purpose, then there might have existed some sort of correlation between that purpose and lowered grade expectations. Grade imbalances were preferred to grade distributions in each purpose because the course had a curved grading scheme; One third of the students received A's, one third received B's, and one third received C's, with a small number of D's and F's. Thus, the above average students outnumbered the below average students almost 2 to 1, making it very likely that every purpose would have twice as many above average students as below average students. Looking at grade imbalances separated the purposes by how large a proportion of each grade level (above or below average) each purpose made up.



To compare the purposes of homework cited by the students and their professor, this study shall classify each purpose using Bloom's Taxonomy in the cognitive domain. Purposes that include: 1) "Recall" or "review" shall be classified under "Knowledge;" 2) "interpret," "compare," and "organize" shall be classified under "Comprehension;" 3) "Integrate," "extend," or "apply" shall be classified under "Analysis;" 4) "New," "alternative," or "challenge" shall be classified under "Synthesis;" 5) "Evaluate" or "judge" shall be classified under "Evaluation."

Analysis of Purposes

This study selected six common academic purposes of homework (Cooper, Robinson, Patall, 2006). These included (1) the practice or review of previously presented material (Becker & Epstein, 1982), (2) the introduction of new material (Muhlenbruck, et al, 2000), (3) the extension and integration of old material with new (Lee & Pruitt, 1979), (4) the evaluation of the student's understanding (Coutts, 2004), (5) the development of time-management skills (Coutts, 2004), and (6) the development of work ethic (Coutts, 2004). Purposes 1-3 represented instructional purposes, while Purposes 4-6 represented non-instructional purposes (Epstein, 1988).

Purpose 1, relating to practice and review, was classified as Knowledge under Bloom's Taxonomy because of the use of “practice” and “review.” Purpose 2 was classified as Synthesis because of the use of “new material,” while Purpose 3 was classified as Analysis because of the use of “integrate” and “extend.” Purpose 4, however, was only tentatively classified as Evaluation, because while it did involve evaluation of understanding, it was in regard to the *student's* understanding, not a particular concept that was part of the course. Purposes 5 and 6 were classified as being non-cognitive.

Context of Study

This study took place during the Spring 2010 semester of Math 1920, Multi-Variable Calculus for Engineers in the College of Arts and Sciences at an Ivy League university in the United States. Students had prior knowledge of differential and integral calculus in one variable, and this was generally their first course involving multiple variables. The goals of the class were to introduce the concepts of multi-variable calculus in preparation for its application in the various engineering disciplines offered at the university. Unit topics included: partial derivatives, double and triple integrals, line integrals, vector fields, Green's theorem, Stokes' theorem, and

the divergence theorem.

Students attended 50-minute lectures three times a week, run by a Senior Lecturer of Mathematics, referred to as Professor T. Professor T was highly involved in efforts to improve mathematics education at the university, most notably the GoodQuestions project, created to develop materials to help instructors engage students in meaningful discussions about key concepts in calculus.

Students also attended two 50-minute recitation sections per week, facilitated by graduate Teaching Assistants, generally Ph.D. candidates in Mathematics or Applied Mathematics, with the occasional Master's candidate in fields ranging from engineering to education. These sections were capped at a 29 student limit. Lectures were designed as presentations of material and recitations were meant for review and personalized attention to students in that section.

The class grades were curved, such that approximately a third of the students received A's, a third received B's, and a third received C's, with a very small amount of D's and F's. The components factoring into the final course grades were as such:

1. Two mid-term exams, given in the evening, one in late February, the other in mid-April, each consisting of 25% of the student's total grade. Students were allowed to perform corrections on their exams, whereby students supplied correct solutions to problems that did not receive full-credit on the original exam along with explanations of their correct answers, earning $\frac{1}{4}$ of their lost points for a correct solution and $\frac{1}{4}$ of their lost points for a correct explanation.
2. One cumulative final exam, consisting of 40% of the student's grade. No corrections were allowed for the final.
3. Homework counted as 10% of the student's grade, fulfilled completely by participation, measured as the number of problems reasonably attempted divided by the number of total problems assigned. Reasonably attempted

means to have written more than a simple re-statement of the question.

Homework assignments consisted of problems drawn from a well-known calculus textbook, with approximately 15-25 problems each week from the chapters covered during lecture. At the beginning of the semester, feedback on homework consisted of two grades for each assignment, one for participation, which consisted of simply counting the number of problems reasonably attempted and a graded component, whereby two problems out of those assigned that week were chosen and graded to a rubric designed to be similar to an exam rubric. Later in the semester, these graded problems were deemed to be more work than they were worth, and thus students were given only their participation grade as feedback on their homework. Homeworks were graded by the teaching assistant of each student's recitation section and homework feedback beyond the requisite participation grade was left to each teaching assistant's preference.

Results

Student Opinions

Out of the 400 students who took the course, 224 filled out the survey, 68% of whom chose Purpose 1 for Question 13, or that homework's chief purpose was to review or practice previously presented material. This represented the lowest level of cognition on Bloom's Taxonomy. 79% of students chose Purposes 1-3, the instructional purposes, while only 21% of students chose non-instructional Purposes 4-6, as shown in Table 1.1:

Table 1.1 Breakdown of Student Responses to Question 13			
Purpose	Percentage	Instructional vs. Non-Instructional	Low-level Cognition vs. High-level Cognition
1	68%	Instructional - 79%	Low-level - 68%
2	2%		High-level - 26%
3	9%		
4	15%	Non-Instructional - 21%	Non-cognitive - 6%
5	4%		
6	2%		

With respect to how well the homework fulfilled the purpose given by each student, 65% of the students responded with either 4 or 5 to Question 14, saying that they agreed with the statement that the homework helped them achieve their purpose of homework. The distribution of responses in Purposes 1-4 were similar to the overall class responses, while Purposes 5 and 6 seemed more extreme. This was most likely due to the small number of students who gave Purposes 5 or 6 as the primary purpose of homework, so no strong conclusions could be made. For Purposes 1-4, it appeared that the students' beliefs on the purpose of homework did not cause an imbalance on *their perception* of the effectiveness of the homework in serving their purpose.

Table 1.2 Breakdown of Student Responses to Question 14						
Purpose	Number of Students	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Total	224	4%	11%	20%	41%	24%
1	152	3%	9%	23%	41%	23%
2	4	0%	25%	25%	50%	0%
3	20	0%	15%	25%	45%	15%
4	33	6%	13%	10%	42%	29%
5	9	11%	11%	0%	33%	44%
6	5	20%	40%	0%	20%	20%

Professor's Opinion

When asked about the purpose of homework in her class, Professor T expressed the diverse and informed opinion of a professor well in touch with the complex issue of the purpose of homework:

Homework serves three purposes: a) to encourage students to keep up in a timely manner and to work through (and practice) straightforward problems on current material, b) to challenge students to apply what they are learning to more challenging/thought provoking problems than can be discussed in class, c) to review and synthesize new material with previously learned material.

Professor T's opinion overlapped with almost every single purpose of homework given to the students as part of their survey. "To encourage students to keep up" was very similar to Purpose #6, "to improve my study habits," while "to work through (and practice) straightforward problems on current material" was similar to Purpose #1, "to practice and review material already presented in lecture," in the Knowledge classification under Bloom's Taxonomy. "To challenge students to apply what they are learning to more challenging/thought-provoking problems" can also be classified as Analysis or Synthesis, due to the use of both "apply" and "challenge," similar to Purposes 2 and 3. "To review and synthesize new material with previously learned material" also seemed to combine elements of Knowledge and Analysis, similar to Purposes 1 and 3. When asked what she felt most of the *students* believed was the primary purpose of homework, Professor T answered with Purpose 1, indicating that her expectation of the students was in line with the student responses, given that 68% of the students who answered the survey gave Purpose 1.

Professor T also said that the homeworks were designed with different types of problems in mind, each with varying levels of success for the students, saying:

a) I think that the routine problems succeeded in accomplishing my

goals.

b) I think the challenging problems succeeded for some students--perhaps the 25% who ultimately earned A's did find some of the challenging problems interesting.

c) I think that the synthesizing problem that I assigned were few and far between--in part because the text does not have many good problems of that type. Also I think that students found those problem very difficult.

For routine problems assigned for practice and review, the students and their Professor seemed to be in agreement, since 64% of students who gave Purpose 1 agreed with the statement that the homework helped achieve that purpose. However, For the challenging problems meant to provoke thought, Professor T believed that only 25% of the student body, mainly those who ultimately received outstanding grades, benefited from those problems. 60% of students who responded with Purpose 3 felt that the homework helped them achieve it, but without knowing how the students who gave *other* purposes felt about the challenging problems, no strong conclusions could be made. For problems meant to synthesize new material with old, the majority of students who responded with Purpose 1 and 3 felt that the homework helped them achieve those purposes, so the few number of problems that were there may have benefited some of the students. Similar to the case of challenging problems, due to the lack of information about how students who gave *other purposes* felt about the synthesizing problems, no strong conclusions could be made.

Lastly, Professor T intended for the homeworks to require 6-8 hours per week to complete, which was used when analyzing time spent on homework and expected grades below.

Instructional vs. Non-Instructional

When comparing the other responses of students who chose instructional purposes of homework, who shall be called “instructionals” for the sake of brevity, versus students who chose non-instructional purposes of homework, or “non-

instructionals,” certain patterns emerged regarding the adequacy of exams, the difficulty of the course, and the amount of time spent on homework.

Table 2.1 Student responses on exam difficulty, course difficulty, and time spent on homework per week			
Purposes	% 4 or 5 to Q8, “exam difficulty” (%5 in parentheses)	% 4 or 5 to Q9 “course difficulty” (%5 in parentheses)	% 4 or 5 to Q11 “homework time” (%5 in parentheses)
Instructional (1-3)	57% (16%)	64% (14%)	16% (3%)
Non-Instructional (4-6)	72% (23%)	72% (26%)	30% (9%)

72% of non-instructionals responded 4 or 5 on Question 8, claiming that the exams were too difficult, while 57% of their instructional peers claimed the same. This indicated that non-instructionals tended to have greater difficulty with exams than their instructional peers. 72% of non-instructionals responded 4 or 5 on Question 9, claiming that the course in general was too hard, contrasted with only 64% of their instructional peers. Also, 26% of non-instructional responded 5 on Question 9, while only 14% of instructionals did the same. This indicated that, the non-instructional students tended to have greater difficulty with the exams and the course in general. Professor T also said that she intended for homework to require 6-8 hours per week from the students. However, 30% of non-instructionals spent more time on homework than intended by Professor T compared to 16% of instructionals. Thus, non-instructionals generally spent more time on homework than instructionals.

These general trends seemed to indicate that non-instructionals in the course had more difficulty with exams and the course, but spent more time on homework than their instructional peers. Professor T did say that one of the primary purposes of homework to her was “to encourage students to keep up in a timely manner,” indicating a slight interest in non-instructional purposes, but the rest of her purposes were instructional. While this was not an indication of causation, it is a possibility

there exists a correlation between her *not* citing non-instructional purposes, and non-instructionals having difficulty with the course.

Purpose of Homework and Grade Expectations

The grade levels were broken into two categories, Above Average (students expecting A's or B's) and Below Average (students expecting C's, D's, or F's). Each level was differentiated by purpose, looking for imbalances, shown in Table 3.1:

Table 3.1 Breakdown of Student Expected Grades by Purpose						
Expected Grades	Purpose 1	Purpose 2	Purpose 3	Purpose 4	Purpose 5	Purpose 6
Above Average (A or B)	66%	0.5%	11%	19%	3%	0.5%
Below Average (C, D, or F)	73%	4%	5%	7%	6%	5%
Mean expected grade (A=4, B=3, etc.)	2.77	2.00	3.20	2.94	2.22	1.80

Purposes 1 and 2 both made up a greater proportion of the students expecting a C, D, or F grade than of the students expecting an A or B grade. Meanwhile, students who cited Purposes 3 and 4 made up 30% of the above average students while making up only 12% of the below average students. Only 4 students selected Purpose 2, so no conclusions could be drawn about its effect on expected grades. The average responses of students selecting Purpose 1 was 2.77 (4 being an A, 0 being an F), while the average responses of Purpose 3 and 4 were 3.20 and 2.94, respectively. These imbalances in the expected grades of Purposes 1 (making up a greater proportion of below students), 3, and 4 (making up a greater proportion of above average students) indicated that students who treated homework as a higher cognitive activity expected

better grades on average and made up a greater proportion of above average students than below average students. Non-instructional purposes, Purposes 5 and 6, made up 11% of below average students, while only making up 3.5% of above average students, with an average response of 2.22 and 1.80 for Purposes 5 and 6, respectively, which was much higher than their instructional peers. These imbalances seemed to indicate that students who cited non-instructional purposes of homework expected worse grades on average and made up a greater proportion of below average students than above average students.

Time Spent on Homework

Professor T said that the homework assignments were intended to take 6-8 hours of work per week. Students who tended to spend more time on homework than prescribed by Professor T tended to have a *lower* expected grade.

Table 4.1 Breakdown of Expected Grade by Time Spent on Homework by Number of Students					
Expected Grade	< 2 hours	2-4 hours	5-8 hours	9-15 hours*	> 15 hours*
Above Average (A or B)	1%	24%	62%	11%	2%
Below Average (C, D, or F)	1%	22%	48%	22%	7%
Mean expected grade (A=4, B=3, etc.)	2.67	2.84	2.87	2.55	2.57
*Greater than amount of time specified by Professor T					

While similar percentages of both groups of students worked on homework for less than 2 hours and 2-4 hours per week, 62% of students who expected A's and B's spent 5-8 hours per week on homework, compared to 48% of C, D, and F expecting students. This imbalance seemed to indicate that students who spent an amount of time on their homework that was in the range prescribed by Professor T made up a

greater proportion of above average students than below average students.

Surprisingly, a much larger proportion of C, D, and F expecting students responded that they spent *more* time on homework than specified by Professor T. 29% of C, D, and F expecting students spent more than the intended 6-8 hours on homework, while only 13% of A and B expecting students did so. Also, the average response of students who spent 9-15 hours and greater than 15 hours per week on homework was 2.55 and 2.57, respectively, much larger compared to 2.67, 2.84, and 2.87 for less than 2 hours, 2-4 hours, and 5-8 hours, respectively. This presented a tentative positive correlation between time spent on homework and expected grade up to 5-8 hours, then a negative correlation beyond that.

Summary and Conclusions

This study was an introductory attempt to study three questions regarding mathematics homework at the introductory college level: 1) “Do introductory college mathematics students hold different beliefs about the purpose of homework compared to secondary and elementary school students?” 2) “Does their professor hold a different belief about the purpose of homework, and does this affect the students in any way?” 3) “Do introductory college mathematics students have an even greater correlation between time spent on homework and achievement than their secondary school counterparts?”

For the first question, the introductory college mathematics students in this class overwhelmingly supported instructional purposes of homework. Within the instructional category, the majority of students in the class believed that the primary purpose of homework was to practice and review previously presented material, similar to students in secondary school (Coutts, 2004). Purpose 1, the practice and review of previously presented material, consisted of learning the mechanisms and conventions of mathematics through repetition, the most rudimentary level of learning

in Bloom's Taxonomy. This suggested that the students in the class were still operating on the belief that homework was an exercise in repetition and was not fundamentally a learning tool; it was not meant to explore ideas in greater depth. Very few students identified with the purely non-instructional purposes. This outcome was in line with the high school literature on homework, where students also showed very little concern for the non-instructional purposes of homework in secondary school (Coutts, 2004).

For the second question, the student responses were first separated into categories of instructional and non-instructional (Epstein, 1988). The purposes of homework were then classified using Bloom's Taxonomy and compared to their professor's opinions on the purpose of homework. Professor T also focused mostly on instructional purposes, and students who chose primarily instructional purposes tended to expect better grades than those who chose primarily non-instructional purposes. More non-instructional students felt that the exams were not fair assessments of their knowledge, while they also felt that the course in general was too difficult. However, more non-instructional students also reported spending more than the intended 6-8 hours per week on homework. Since Professor T gave mostly instructional purposes of homework, it may have been that the homework was simply not geared toward self-development, thus less beneficial to non-instructional students. It could also have been that the students simply struggled with the homework until they gave up as opposed to their choice for the purpose of homework negatively affecting their expectations. Thus, no strong conclusions could be made.

Grade-wise, Purpose 1 students made up a greater proportion of those who expected below average grades than those who expected above average grades. Also, the proportion of A and B students who chose Purposes 3 and 4 was much larger than the proportion of C, D, and F students who chose those same purposes. Since Professor T gave many higher cognitive purposes of homework, this seemed to

indicate that students who also chose higher cognitive purposes of homework tended to expect better grades in the class. Students who chose non-instructional purposes were more likely to expect below average grades. This poor expectation may have been attributed to the difference in ideas on the purpose of homework between the non-instructionals and Professor T, causing the non-instructionals to get less benefit out of their homework. Although Professor T held no false beliefs about her students, unlike some professors from John Volmink's study (Volmink, 1983), it appeared that similarly, non-instructional students who held different ideas on the purpose of homework than the professor tended to expect slightly worse grades than their peers. This, however, was tentative at best, since it might have been the case that non-instructional students struggle in all introductory math classes, and not just because their professor differs in opinion from them in this particular class.

For the third question, students who spent less than or equal to the amount of time on homework specified by Professor T tended to expect better grades than those who spent more time than specified by Professor T. This seemingly disagreed with an extension of the work of Muhlenbruck and others (Muhlenbruck, et al 2000), that introductory college students should exhibit a greater positive correlation between time spent on homework and grade expectations than their secondary school counterparts. While this did not exhibit causation between the students spending more time on homework and poor performance, it did at least show that a positive correlation was questionable.

Limitations

The conclusions of this study were fairly tentative, there were certain limitations that could not be ignored. As with any student-reported survey, student responses were open to interpretation. Certain students obviously filled out the survey much too quickly, an example being two students who responded with choice 5 for

every question, namely Question 7, a claim that indicated that the homeworks were very valuable to the students, while commenting in Question 16 that the homework was useless, a direct contradiction. While these cases were obvious and thus removed from the study, it pointed to the fact that student responses, especially electronic responses, may be inaccurate. Also, students may not actually have put much critical thought into the purpose of homework, and Purpose 1 sounding legitimate and reasonable may have caused many students to simply select the first choice.

As with any statistical study, student sample size was another outstanding issue. While 224 students did fill out the survey, this represented only approximately 56% of the total student population in the course. And due to the overwhelming majority of students who selected Purpose 1, sizes became further constrained when looking at the number of responses to each purpose, some purposes having as few as four responses. Lastly, the fact that this study took place at an Ivy League university, an elite university with students that seemingly represent the best of their class, may have greatly skewed their opinions towards homework, similarly to students in high school who are successful having different opinions than their peers who are less successful.

Further Study

It is clear that the purpose of homework at an introductory collegiate mathematics level has not been fully investigated by academia. While there exists numerous research done at the elementary and secondary school levels, few studies extend themselves to the college environment. This seems unfortunate since presumably that is the area for which elementary and secondary schools are preparing their students. For this reason, it is clear that more research needs to be done on homework at the collegiate level, specifically the purpose of homework at the collegiate level.

While it is beyond the scope of this study, the relationship between exams and homework needs to be further explored at the college level. The fact that such student-teacher dissonance exists regarding the relationship between homework and exams indicates that there is a need to examine the methods of communication between teachers and students.

The other key conclusion from this study was that a positive correlation between time spent on homework and achievement was dubious at best. This needs further verification at a wider scale, since it is a fundamental difference between how homework is viewed at the elementary and secondary school levels compared to the collegiate level.

Lastly and perhaps most importantly, the set of purposes of homework comes from research based on the opinions of elementary and secondary school administrators, teachers, parents, and students. While there almost certainly exists anecdotal evidence regarding differences between these views at the elementary and secondary school levels versus the collegiate level, a firm record of college professor and administrator's views on the purpose of homework needs to be established.

One issue remains clear: more work must be done to understand the purpose of homework at the collegiate level, particularly in mathematics. The greatest issues uncovered by this study were the imbalances in grade expectation from the purposes of homework cited by the students and their professor, as well as the possibly negative correlation between time spent on homework beyond the amount expected by the professor and achievement. To make any generalized conclusions, however, requires more research to be done.

APPENDIX

Transcript of email correspondence with Professor T (responses in italics).

1.) In your opinion, what was the purpose of homework in Math 1920 this past spring?

Homework serves three purposes: a) to encourage students to keep up in a timely manner and to work through (and practice) straightforward problems on current material, b) to challenge students to apply what they are learning to more challenging/thought provoking problems than can be discussed in class, c) to review and synthesize new material with previously learned material.

2.) In your opinion, did the homeworks as they were constructed, achieve their purpose this past semester? Do you have any sense as to whether the homeworks really benefited the students?

*a) I think that the routine problems succeeded in accomplishing my goals.
b) I think the challenging problems succeeded for some students--perhaps the 25% who ultimately earned A's did find some of the challenging problems interesting.
c) I think that the synthesizing problem that I assigned were few and far between--in part because the text does not have many good problems of that type. Also I think that students found those problem very difficult.*

3.) A number of students felt that the assignments were so long that they did not have time to think about each problems and instead were just working mechanically through them. Do you feel there is any truth to this?

I designed the HW to take about 6-8 hours /week. Students are not accustomed to spending that kind of time. I chose problem pretty carefully and with a few exceptions (I'd say 2 week assignments at most) I was careful not to assign repeat problems unless I felt there were techniques they NEEDED to practice. Most problems required something different.

4.) What do you believe the students think is the primary purpose of homework?

From the list given in Q 13 below I think #1 is what students think the primary purpose is.

5.) Do you believe that the students' beliefs on homework have any effect on the benefits of the homework?

Absolutely! If students' expectations are that HW is for practicing things they have been shown how to do, it is difficult for them to believe or accept that HW may rightly have additional purposes--such as previewing and warming up for class by reading material before it is discussed in class. Also students find it "unfair" to be expected to use what they are learning in novel ways on HW, even though that is how they will be

assessed on exams--not just doing routine problems but synthesizing and applying what they have learned in unfamiliar contexts. Of course student find these types of exam questions "unfair" as well since they "have not been shown how to work a problem like" the exam problem. It seems odd to me that they do not value the opportunity to test their ability to use what they are learning through the process of working more challenging HW.

Survey given to students

1. Did the lecturer stimulate your interest in the subject?
1 = not at all
5 = stimulated great interest; inspired independent effort
2. Was the lecture presentation organized and clear?
1 = disorganized and unclear
5 = very organized and lucid
3. Was the lecturer willing and available to help you overcome difficulties in this course?
1 = was of no help
5 = was very helpful
4. Rate the overall teaching effectiveness of your lecturer compared to others at Cornell.
1 = worse than average
5 = much better than average
5. Was the homework returned in a timely manner?
1 = never
5 = always
6. Were the grader's comments helpful?
1 = no help
5 = very helpful
7. How valuable were the homework assignments?
1 = taught me little
5 = extremely educational
8. Rate the examinations in this course as a test of your knowledge.
1 = too easy, not adequate
3 = adequate
5 = too difficult, not a fair test
9. Rate the level of difficulty of this course.
1 = too easy
5 = much too hard
10. How suitable was the textbook?
1 = lousy
5 = great
11. How many hours each week (on the average) did you spend on this course outside of class?
1 = less than 2 hours
2 = 2-4 hours
3 = 5-8 hours
4 = 9-15 hours
5 = 16 hours or more

Survey (Continued)

12. If you have previously taken calculus at Cornell in the small-lecture format, how would you compare that format to the large lecture and small recitation group format of this course?

1 = much prefer small lecture format

5 = much prefer large lecture format

13. Choose which statement best reflects your beliefs: I believe that the chief purpose of homework in this course should be to...

1 = help me practice and review material already presented in lecture.

2 = introduce me to new material as preparation for a future lecture.

3 = help me integrate previously learned material with new material.

4 = help me evaluate what parts of the material I do not understand.

5 = encourage me to learn during leisure time.

6 = improve my study habits.

14. State how strongly you agree or disagree with the following statement: The homework in this course helps me to achieve the purpose chosen above.

1 = strongly disagree

5 = strongly agree

15. Without taking into account the final exam, which do you believe is closest to your current grade in this course?

1 = A

2 = B

3 = C

4 = D

5 = F

16. Please comment on any aspect of this course.
(e.g., the lecture, text, homework, examinations, or course content)

17. Would you recommend this course to other students? Please explain.

18. Please expand on any answers to questions 13-15 that you feel deserve clarification.

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